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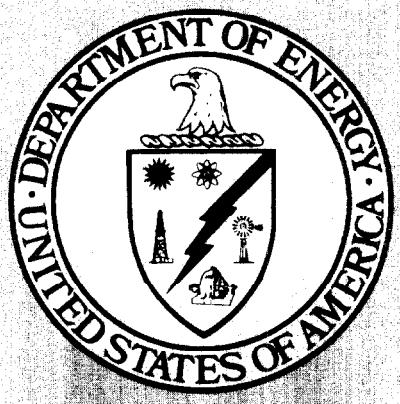


METC/CR-80/1

# THE CHATTANOOGA SHALE (DEVONIAN AND MISSISSIPPIAN) FROM THE TENNESSEE DIVISION OF GEOLOGY - U.S. DEPARTMENT OF ENERGY CORED DRILL HOLES NUMBER 1 AND 2, CLAIBORNE COUNTY, TENNESSEE

By

John B. Roen, Robert C. Milici,
Roy C. Kepferle, and Laure G. Wallace

January 1980

Work prepared by
U.S. Geological Survey

Under Contract No. DE-AI21-79MC10866.

For

UNITED STATES DEPARTMENT OF ENERGY
Morgantown Energy Technology Center
Morgantown, West Virginia

TECHNICAL INFORMATION CENTER
UNITED STATES DEPARTMENT OF ENERGY

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## ILLUSTRATIONS

# The Chattanooga Shale (Devonian and Mississippian) from the Tennessee Division of Geology - U.S. Department of Energy Cored Drill Holes Number 1 and 2, Claiborne County, Tennessee

by

John B. Roen,[1] Robert C. Milici,[2]

Roy C. Kepferle,[3] and Laure G. Wallace'

## INTRODUCTION

The Tennessee Division of Geology under contract to the Morgantown Energy Technology Center of the U.S. Department of Energy has drilled eight NX core holes in eastern Tennessee. The coring program, under the supervision of R. C. Milici, was designed to retrieve continuous core sections for a detailed characterization study of the Chattanooga Shale. The Geophysical wire-line logging for the NX drill holes was performed by the U.S. Geological Survey.

1/ LJ. S. Geological Survey, Reston, Virginia

2/ Tennessee Division of Geology; present affiliation, State Geologist, Division of Mineral Resources, Commonwealth of Virginia

3/ U. S. Geological Survey, Cincinnati, Ohio

The characterization study in conjunction with two seismic surveys conducted by Geophysical Service, Inc., for the Tennessee Division of Geology and the U.S. Department of Energy will be used to evaluate the hydrocarbon potential of the Chattanooga Shale in northeastern Tennessee.

The purpose of this report is to present a detailed lithologic description and gamma-ray log of the Tennessee Division of Geology and U.S. Department of Energy cored drill holes No. 1 and 2 (TDG-DOE No. 1 and No. 2).

TDG-DOE No. 1 core hole, Tennessee State coordinates 767, 150N; 2,756,500E, is located on the Fred Pearson farm in the Howard Quarter 7 1/2-minute quadrangle, Claiborne County, Tennessee (Fig. 1). The hole was spudded at the ground elevation of 1100 ft. Preliminary study of the No. 1 core indicated that the upper part of the Chattanooga Shale was not encountered although more than 230 ft of Chattanooga and more than 20 ft of the underlying Hancock Dolomite were penetrated. The rig was moved to a nearby site, TDG-DOE 2, and approximately 70 additional feet of core were recovered from the upper part of the Chattanooga. The ground elevation TDG-DOE No. 2 is 1120 ft; the Tennessee State coordinates are 765,900N; 2,755,300E.

Positive correlation of the two cores was based on three thin distinct greenish-gray shale beds occurring in both cores and their radioactive response recorded on the gamma-ray logs. Figure 3 is a composite columnar section and gamma-ray log of TDG-DOE No. 1 and No. 2, showing about 38 ft of overlap.

## GEOLOGIC SETTING

The coring sites are in the western half of the Appalachian Valley and Ridge province where the Chattanooga Shale outcrop belt wraps around the southwestern end of the Newman Ridge syncline (Figure 2). The Valley and Ridge province is a tectonic region of folds and imbricate thrust faults in rocks of Paleozoic age. The Newman Ridge syncline, which contains a bedding plane fault near the base of the Chattanooga, is bounded on the west by the Wallen Valley thrust fault and on the east by the Clinchport and Hunder Valley thrust faults. The Hunter Valley thrust is west of the Clinchport thrust where its trace indicates that it has been folded and truncated by the Clinchport. The strike and the outcrop pattern of Chattanooga Shale along the southeastern flank of the Newman Ridge syncline indicate that the Chattanooga passes beneath the western edge of the upper plate of the Hunter Valley thrust. The Chattanooga is exposed along the northwestern flank of the syncline in Claiborne and Hancock Counties. The Chattanooga Shale unconformably overlies the Hancock Dolomite of Silurian age and is overlain by the Grainger Formation of Mississippian age.

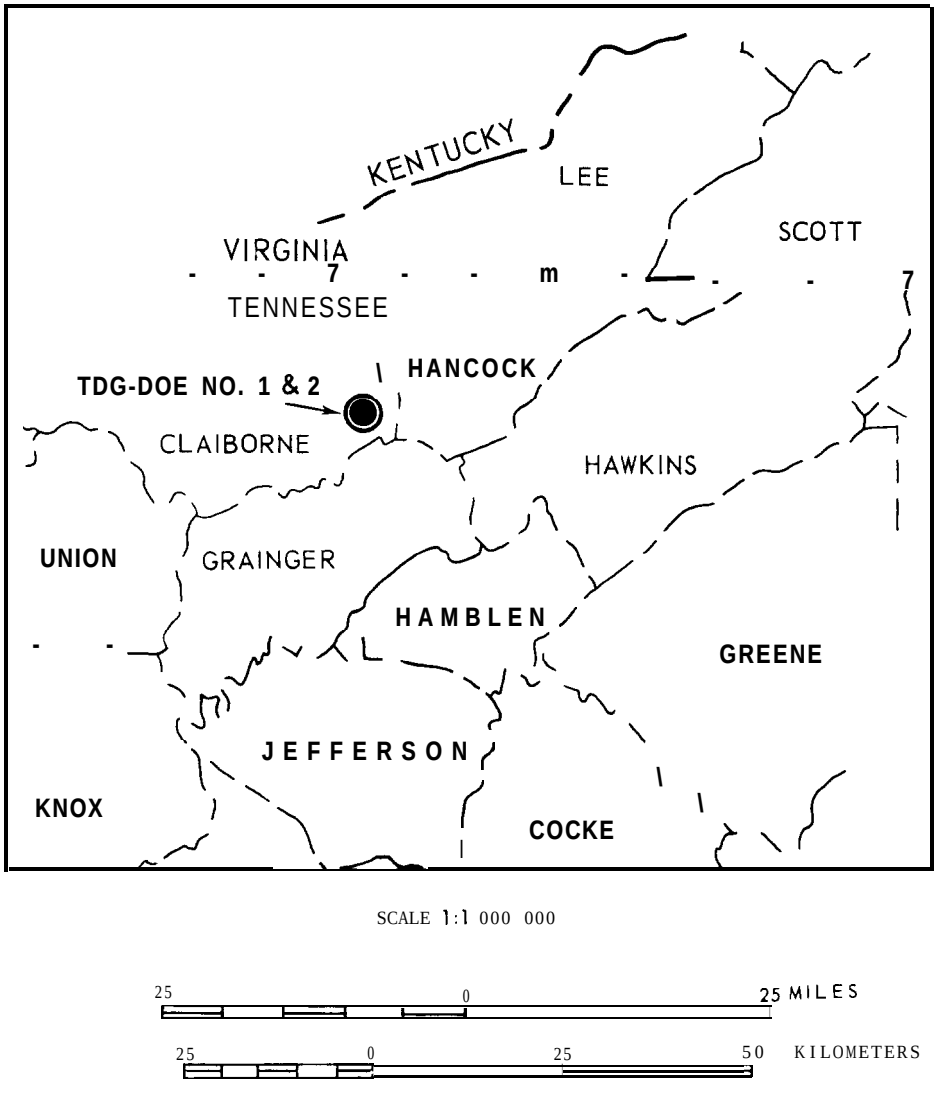


Figure l.--Index map showing location of cored drill holes.

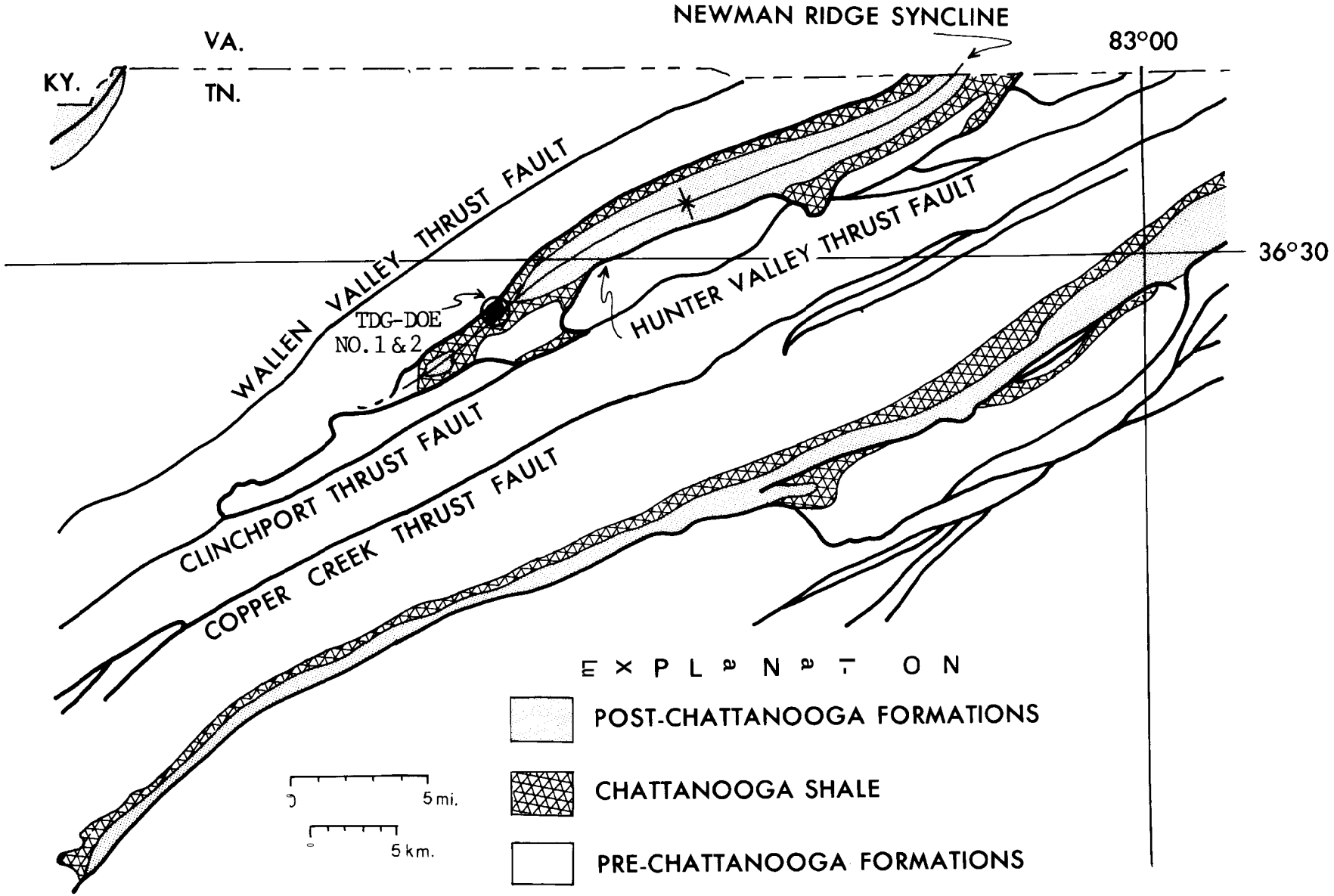


Figure 2.--Generalized map showing the locations of TDG-DOE cored drill holes No. 1 and No. 2. Modified from Swingle and others (1966).

## LITHOLOGIC DESCRIPTIONS

## TDG-DOE Cored Drill Hole No. 1

| Depth[1]/ | Chattanooga Shale |
|---|---|
| 0 - 9.3 | Casing, no core recovered. |
| 9.3 - 20.7 | Shale, black (N 1)[2]/ to grayish-black (N 2), laminated to very thin bedded, platy, about 10 percent thick-bedded. Bedding defined by siltstone beds less than 0.05 ft thick. Siltstone beds are dolomitic and pyritic. Gypsum-filled fracture zones occur approximately every 0.5 ft, slickensided. Tasmanites present. Few very thin beds of olive-gray (5 Y 3/1) shale near top of unit. Dip - 20". |
| 20.7 - 23.1 | Shale, olive-gray (5 Y 4/1) to dark greenish-gray (5 GY 4/1), silty and clayey. Contains disseminated pyrite. Slickensided, base sharp. |
| 23.1 - 27.9 | Shale, grayish-black (N 2) to black (N 1), thin to very thin bedded, contains siltstone laminae 1 to 2 grains thick. Burrowed, contains Tasmanites. Slickensided. Few very thin beds of olive-gray (5 Y 3/1) shale. |
| 27.9 - 29.5 | Shale, olive-gray (5 Y 4/1) to dark greenish-gray (5 GY 4/1), thick-bedded, contains pyrite nodules as much as 0.02 ft in diameter. |
| 29.5 - 32.1 | Shale, grayish-black (N 2) to olive-black (5 Y 2/1), contains a 0.07 ft thick bed of greenish-gray (5 GY 6/1) shale at 30.5 ft and a siltstone laminae 0.02 ft thick at 30.9 ft. Thin to very thin bedded. Contains pyrite nodules and Tasmanites. Burrowed in upper 0.1 ft. |
| 32.1 - 35.8 | Shale, greenish-gray (5 GY 4/1), irregular pyrite nodules as much as 0.04 ft in diameter common 0.6 ft below top and 0.2 ft above base. Lingula present near base. Color gradational to unit below. |

1/ Measured in feet, meters not applicable

2/ Color symbols are those of Goddard and others (1948)

| | |
|---|---|
| 35.8 - 72.0 | Shale, black (N 1), grades downward to brownish-black (5 YR 2/1) and olive-black (5 Y 2/1), color-banded. Thin to very thin bedded. Siltstone laminae as much as 0.02 ft in thickness, commonly 1-2 grains thick, pyritic. Burrows filled with pyritic siltstone. Tasmanites, Lingula, and fish scales present. Fractures filled with gypsum and pyrite; siltstone laminae as much as 0.05 ft thick at 63.2 ft. |
| 72.0 - 108.0 | Shale, brownish-gray (5 YR 4/1), brownish-black (5 YR 3/1), and olive-black (5 Y 2/1); banded with 10 percent olive-gray (5 Y 4/1) shale in very thin beds as much as 0.07 ft thick. Increasing amounts of yellowish-brown (10 YR 5/2) siltstone toward base of unit. Siltstone laminae commonly less than 0.02 ft thick, pyritic. Siltstone cut by faults with offset of 0.05 ft or less. Fractures common throughout. Dip 30° to 100 ft. Tasmanites sparse. |
| 108.0 - 128.2 | Shale, as above. Foerstia zone 108.0 to 120.2 ft; round form near top of zone; elongate, narrow, branching form near base of zone. Olive shale diminishes downward. Fault gouge at 121.0 to 122.1 ft. Dip 25" at 110 ft. Tasmanites common near base of unit. |
| 128.2 - 160.7 | Shale, brownish-gray (5 YR 4/1) to brownish-black (5 YR 3/1), banded with olive-gray (5 Y 3/1) shale. Laminated to very thin bedded, locally fissile fractured and slickensided from 142.2 ft to 142.5 ft, and from 144.6 ft to 144.9 ft. Dip 15" at 150 ft. Pyritic, Tasmanites locally abundant. |
| 160.7 - 176.2 | Shale, olive-gray (5 Y 4/1), mottled, burrowed, pyritic, thin- to thick-bedded. Interbedded with lesser amounts black (N 1) and brownish-black (5 YR 2/1) shale. Slickensides present at 165.4 ft to 165.8 ft, 175.7 ft to 176.0 ft. |
| 176.2 - 194.3 | Shale, brownish-black (5 Y 2/1), mottled, burrowed, pyritic, very thin to thick-bedded. Interbedded with shale, black (N 1). Unit becomes increasingly olive gray toward base. Slickensides at 176.7 ft to 176.9 ft; 180.0 ft to 180.1 ft, 183.5 ft to 183.7 ft, 184.5 ft to 184.7 ft, and 189.6 ft to 190.0 ft. Highly fractured. |

| | |
|---|---|
| 194.3 - 231.3 | Shale, olive-gray (5 Y 3/1), gradational beds containing numerous laminae and very thin beds of olive-black (5 Y 2/1) shale. Some interbedded brownish-black (5 YR 2/1) shale. Calcite-filled fractures from 201.0 to 201.5 ft. Rurrows filled with lighter colored shale common. Pyrite common near top of unit as scattered nodules. |
| 231.3 - 231.6 | Shale, grayish-black (N 2), highly slickensided. Contains few widely-dispersed, medium-grained, well-rounded quartz grains and scattered conodonts. |

Hancock Dolomite

| | |
|---|---|
| 231.6 - 241.6 | Dolomite, olive-gray (5 Y 4/1) to medium dark-gray (N 4), slightly silty, very finely crystalline containing thin beds and grains of pyrite concentrated in upper 0.2 ft and scattered below; contains a few clasts of dark-gray shale concentrated along stylolites. Contains calcite-filled fractures. Weathers yellowish brown adjacent to joints. |
| 241.6 - 243.1 | Dolomite, light olive-gray (5 Y 6/1), stromatolitic. |
| 243.1 - 246.1 | Dolomite, olive-gray (5 Y 4/1), very finely crystalline, silty, weathers yellowish brown adjacent to joints, stylolitic. |
| 246.1 - 253.6 | Dolomite, light olive-gray (5 Y 6/1) to olive-gray (5 Y 4/1), stromatolitic, silty, weathers yellowish brown adjacent to joints. |
| 253.6 - 254.0 | Dolomite, olive-gray (5 Y 4/1), very finely crystalline, silty. |

TDG-DOE Cored Drill Hole No. 2

| Depth (ft)[1]/ | Chattanooga Shale |
|---|---|
| 0 - 9.2 | Casing, no core recovered. |
| 9.2 - 44.4 | Shale, brownish-black (5 Y 2/1)[2]/ to grayish-black (N 2). Bedding obscured by fractures. Silt laminae rare, fine-grained crystalline pyrite and carbonaceous flecks present. Slickensides abundant; thin gouge zone at 23.1 ft. |
| 44.4 - 46.0 | Gouge, medium-gray (N 4), friable. |
| 46.0 - 93.3 | Shale, brownish-black (5 Y 2/1) to grayish-black N 2), locally black (N 1) with as much as 50 percent very thin beds of brownish-gray (5 YR 4/1) to olive-black (5 Y 3/1) shale. Interbedded siltstone, brownish-gray (5 YR 4/1) in thin laminae at 64.6, 66.0, 73.7, 78.3, 82.1, 84, and 85.3 ft. Pyrite present as disseminated framboids, crystals, and nodules in silty beds below 53.1 ft. Fractures in unit have displacement of less than 0.02 ft, many filled with calcite and gypsum. Burrows common at boundary of lighter and darker shales. Tasmanites, resinous, common in silty zones. Three platy shale beds, olive-gray, (5 Y 4/1) from 91.1 to 91.3 ft. Dip 35" at 50 ft; 27" at 61.4 ft. |
| 93.3 - 95.6 | Shale, olive-gray (5 Y 4/1) to dark greenish-gray (5 GY 4/1), pyritic, contains burrows. |
| 95.6 - 100.5 | Shale, brownish-black (5 YR 2/1). |
| 100.5 - 102.3 | Shale, olive-gray (5 Y 4/1) to dark greenish-gray (5 GY 4/1), pyritic, contains burrows. |
| 102.3 - 105.6 | Shale, brownish-black (5 YR 2/1) containing thin olive-gray (5 Y 4/1) beds at 103.6 ft and at 105.3 ft. |
| 105.6 - 109.1 | Shale, olive gray (5 Y 4/1). |
| 109.1 - 115.6 | Shale, brownish-black (5 YR 2/1). Siltstone in laminae 0.02 ft thick at 111.0, 111.5, 112.3, 113.2, and 112.6 ft. Unit contains few very thin dolomite-filled veins. Some fracturing present. Dip 27" at bottom of hole. |

1/ Measured in feet, meters not applicable

2/ Color symbols from Goddard and others (1948)

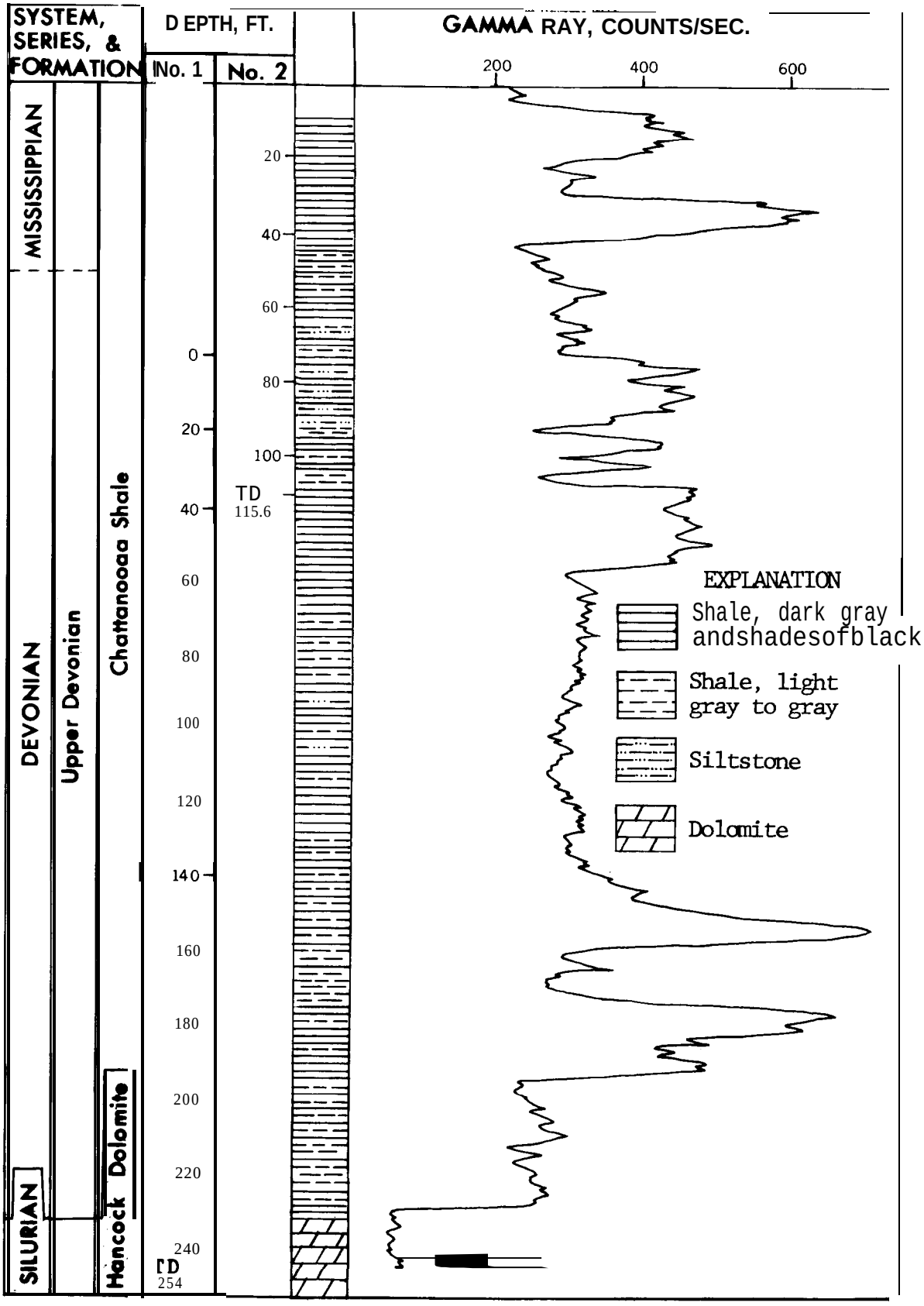


**Figure 3.**--Composited lithologic and gamma-ray logs for TDG-DOE No. 1 and No. 2 cored drill holes. Overlap of logs indicated on depth columns.

## DISCUSSION

The Chattanooga Shale of the Newman Ridge syncline lies stratigraphically above the Silurian Hancock Dolomite and below the siltstone and shale of the Mississippian Grainger Formation.

Combining the cores from the drill holes TDG-DOE No. 1 and No. 2 produced a composite section of the Chattanooga Shale approximately 301 ft thick. The section is not complete however, as neither core hole was spudded in the overlying Grainger Formation. We estimated that 20 - 30 ft of the upper part of the Chattanooga Shale is missing from the composite section. The total thickness of the Chattanooga at the coring sites is estimated to be about 326 ft.

Megascopic examination of the core material indicates that the Chattanooga is predominately a black shale composed of clay, finely divided carbonaceous material, and quartz. Approximately 75 percent of the sequence cored is black or various shades of brownish-black or grayish-black shale. The remaining 25 percent is made up of lighter shades of gray to greenish-gray clay shale and siltstone. Siltsize quartz is disseminated throughout the unit and is also present as very thin beds or laminae of relatively lighter colored siltstone. Locally, the siltstone is dolomitic. The distribution of the darker and lighter shales and the siltstones is shown on Figure 2. The Chattanooga is mostly laminated to very thinly bedded, but some thick to massive beds are present.

Minor to trace amounts of pyrite are common throughout the core. Locally, concentrations of pyrite are found within the siltsone laminae and beds. It occurs *as* irregular nodules, lenses, and framboidal clusters. Calcite and gypsum are found in very minor amounts; probably as fillings of small faults and fractures.

Fossils include the algae Tasmanites and Foerstia, a linguloid brachiopod, and a few conodonts found near the basal contact of the formation. Tasmanites generally occur throughout the sequence, whereas Foerstia was found in the TDG-DOE No. 1 core in a definite stratigraphic zone from 108 - 120.2 ft.

Fractures and slickensided surfaces occur throughout the cored sequence; however, the Chattanooga Shale is not greatly deformed. The most intensely deformed interval is a highly slickensided zone 0.3 ft thick at the base of the Chattanooga Shale. Dips recorded relative to the core axis range from 15 to 35 degrees.

## References

1. Goddard, E. N., and others, 1948, Rock-color chart; Washington, D. C., National Research Council, 6 p. (republished by Geol. Soc. America, 1951).

2. Swingle, G. D., Hardeman, W. D., Fullerton, D. S., Sykes, C. R., and Miller, R. A., 1966, Geologic Map of Tennessee East Sheet: Tenn. Div. of Geol., Nashville, Tennessee.